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THE ZOÖLOGY OF LAKES
AMATITLAN AND ATITLAN,
GUATEMALA, WITH
SPECIAL REFERENCE TO
ICHTHYOLOGY

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CHICAGO, U. S. A.

April, 1908.

The Zoölogy of Lakes Amatitlan and Atitlan, Guatemala, with Special Reference to Ichthyology.

By SETH EUGENE MEEK.

The following paper is the result of a study, under the patronage of the Government of Guatemala, of Lakes Amatitlan and Atitlan for the purpose of determining whether and how the quantity and quality of the useful food and game fishes of these lakes could be increased, and to determine the suitability of the waters for the introduction of species of food-fishes from the United States and elsewhere, and the possibilities of fish-cultural operations. This investigation was undertaken at the request of His Excellency, Señor Don Manuel Estrada Cabrera, President of the Republic of Guatemala. Most attention was given to Lake Amatitlan, which is only twenty miles from the City of Guatemala, and easily accessible to the residents of that city. The field work was done during the months of January and February, 1906. In this I received considerable assistance from Dr. Kellerman and Mr. Smith, of the Ohio State University, who were in Guatemala at this time collecting plants, and from Dr. N. Dearborn and Mr. C. M. Barber, who were then in Guatemala collecting birds and mammals for this Museum. For notes and other aids concerning the plants of this region, I am indebted to Miss Josephine E. Tilden,* of the University of Minnesota, Dr. J. M. Greenman, of this Museum, and Mr. H. W. Clark,† of the U. S. Bureau of Fisheries.

In the study of the collections of animals made during this time, I received the assistance of specialists to whom credit is given in the accounts of the groups studied by each. I also received many courtesies from Dr. B. W. Evermann, in charge of the Division of Scientific Enquiry of the U. S. Bureau of Fisheries. Mr. J. W. Titcomb, in charge of the Division of Fish Culture U. S. Bureau of Fisheries, kindly assisted me in that portion of this paper relating to the recommendations of the most suitable fishes from the United States for introduction into these lakes. I wish to acknowledge my indebtedness to Mr. Combs, U. S. Minister to Guatemala, his secretary, Mr. Brown,

* Proc. Biol. Soc. Wash. 1908, 106-110.

† Proc. Biol. Soc. Wash. 1908, 92-105.

and to Mr. Winslow, U. S. Consul General, for many courtesies; also to Mr. Hodgson and Mr. Tisdal, of the Guatemala Central Railroad, who very materially aided me in transportation. I am especially indebted to Mr. Carlos Palma, of the Consulate of Cuba, who very greatly aided me in my business relations with the Government Officials of Guatemala.

It is, perhaps, not out of place here to state that this investigation grew out of a desire of President Cabrera to do something to increase the value of the food supply of Lake Amatitlan. He therefore asked Hon. George M. Bowers, U. S. Commissioner of Fish and Fisheries, to recommend some person who was properly trained to make the necessary preliminary investigation, to insure the best possible results.

Very little has been done towards the study of the Zoölogy of tropical lakes, which makes the study of these bodies of water of some scientific value. The Government of Guatemala has already begun to establish a Fish Cultural station on Lake Amatitlan, the results of which will be watched with considerable interest.

It might also be well to note here that no attempt was made to collect and study the insects in or about the lake. The species of insects most important in an investigation of this kind are those forms whose larvæ live for a time in the water. During the winter, or dry season, these insects are less active than in the summer, or wet season.



VOLCAN DE AGUA FROM LAKE AMATITLAN

LAKE AMATITLAN.

Lake Amatitlan is situated on the Pacific slope of Guatemala in lat. $90^{\circ} 30' N.$, long. $14^{\circ} 25' W.$ Its surface is about 4,000 feet above sea level, and about 1,000 feet below the plateau on which the City of Guatemala is built. It is strictly a mountain lake, the depression which it occupies having been formed when the surrounding mountains took their present form. It may, therefore, best be considered as



HOTEL LAGUNA, LAKE AMATITLAN

occupying the bottom of a depression in the plateau above mentioned. The lake and its small valley are surrounded by mountains whose average altitude, except the cañon and a few low hills to the southwest, is from about 800 to 1,300 feet above its surface. It occupies an area near the head waters of the Michatoya River, through which its waters find an outlet to the sea. During the earliest portion of its history it was somewhat oval in outline, its greatest width being about 3 miles, its length about 8 miles. The long diameter of the lake is nearly in a northwest and southeast direction. To the northeast is a small valley which is drained into the lake by the Lobos River, the only stream which flows into the lake during the entire year. This stream has the appearance of having shifted its position

many times during the past centuries, and to have been responsible for transporting much of the material which has filled up about two-fifths of the lake. The material worn from the mountains by rain has been transported by the inlet and other small streams to the lake, forming that portion of the low land bordering it to the north and east.



LAKE AMATITLAN FROM ITS UPPER END

This land has so encroached on the lake that now it is narrowest near its middle, where it is only one-fourth of a mile wide. The bottom at this place is of soft mud, apparently to a considerable depth. This is evident from the fact that much trouble was experienced in making a fill across this narrow portion for the railroad. This fill sank out of sight as soon as the soft material of which the bottom of the lake is composed became overloaded. It required much more material to make the railroad fill than the depth of the water indicated.

To the northwest, the mountains consist of hard granite rock and basaltic columns. The other mountains about the lake are mostly composed of loose material, much of it being volcanic ashes, pumice, and other soft material, which is easily eroded. The hills which border



SHORE NEAR OUTLET OF LAKE AMATITLAN



DELTA AT MOUTH OF LOBOS RIVER LAKE AMATITLAN

the valley to the north are composed mostly of this softer material. Even now, in low water, the Lobos River, which drains this valley, rolls along on its bottom a considerable amount of this material, forming at its mouth a small though quite typical delta. The valley about and above Moran shows evidence of considerable erosion, and the material carried away forms a large portion of the low land below this city.

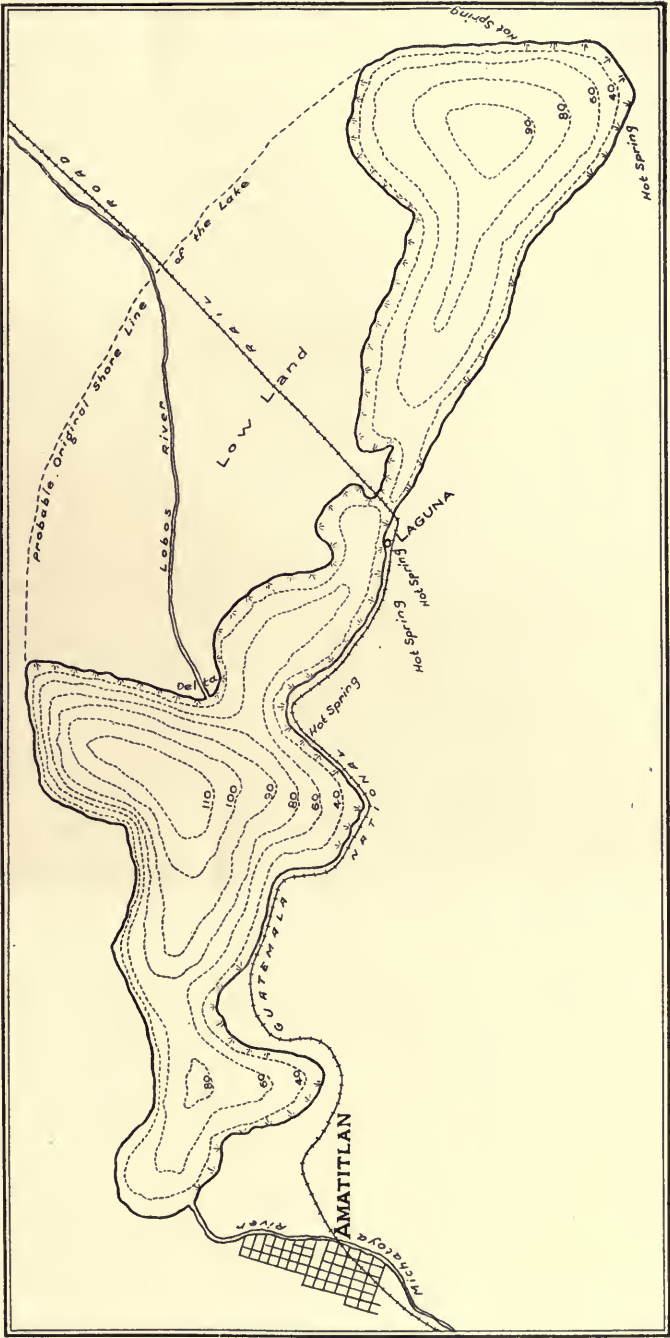
Lake Amatitlan is about 8 miles long, and about $2\frac{1}{2}$ miles wide at either end, and $\frac{1}{4}$ mile near its middle. The fill on which the rail-



DELTA AT MOUTH OF LOBOS RIVER, LAKE AMATITLAN

road is built divides the lake into two parts, or two quite similar basins. The upper is the smaller, and near its center is 95 feet in depth. The lower and larger portion is 110 feet deep. In its narrowest portion, both above and below the railroad, the lake is 50 feet deep.

The bottom of the lake is a quite uniform basin; the lake is deepest where widest, and the slope from shore line to bottom is everywhere steep and quite uniform. The bottom is covered with a light mud, mixed with the remains of small plant life. At a depth of about three feet this mud becomes somewhat firm, and is a clay-like substance of a grayish-blue color. The bottom at the base of the tules is quite firm, being covered with a light mud, sand, and gravel.



CONTOUR MAP OF LAKE AMATITLAN

The temperature of the water in the lake is very uniform. During the time of these investigations, the surface temperature varied from 70° F. at 6:30 A. M. during the last few days in January, to 76° F. at noon to 4 P. M. about the middle of January. The heat of the sun during the day does not warm the water at the surface to a depth of more than 5 to 10 feet, while during the night it cools off quite rapidly. From January 22 to February 1, the temperature of the air at 6:30 A. M. was from 53° F. to 60° F., while during the day it seldom rose to 70° F. These ten days of cool weather did not cool



HOT SPRING, LAGUNA, LAKE AMATITLAN

the water in the lake more than one or two degrees. From my observation it is quite evident that the water in the lake never becomes cooler than 69° F., and that it is never, except near the surface, more than two or three degrees warmer than this. These temperatures were taken with a Nigretti-Zamba deep-sea thermometer. The bottom temperatures taken were not always recorded, for all of these taken at the bottom on any one day were the same.

Along the south and east ends of the lake are a number of warm or hot springs. These springs discharge their waters into the lake at its surface, where it forms only a thin layer of hot water over a small area near the spring, and soon becomes the same temperature as the air. The hot springs influence the temperature of the water in the

lake only a few feet from the shore, and then only at the surface. The many bottom temperatures which I took in all parts of the lake did not indicate any local sources of heat in the bed of the lake. I was unable to secure a thermometer in the City of Guatemala which would register over 110° F. and so I was unable to take the temperature of the water as it came from these hot springs. The largest and hottest one, near the station of Laguna, was hot enough to boil eggs very successfully. In 6 minutes the egg would be soft boiled, at 10 to 12 minutes medium, and at 15 minutes the yolk would be hard but the white was quite soft.

The small fishes (*Pæcilia sphenops*) will swim nearly up to these springs, but they remain in the cooler layer of water near the bottom. They appear to be swimming in water hot enough to scald one's hand, but in reality are in water not warmer than 90° or 100° F. A few of these fishes were placed by me in water taken directly from the spring, and these died almost immediately. These small fishes, although they come very close to the spring, do so in the lower stratum of water. The hot springs on the margin of Lake Amatitlan are too small and too near the surface to have any influence on the general temperature of the water in the lake.

The water is only moderately clear. A white disc 12 inches in diameter cannot be seen at a depth of over 10 to 15 feet, seldom over 12 feet. The same disc is plainly visible in Atitlan at a depth of 45 feet. The lack of clearness is due more to the abundance of Plankton (microscopic animals and plants) in the water than to the fine, silt-like material held in suspension. The water in Lake Amatitlan is slightly alkaline, having a specific gravity of about 1.002 (specific gravity of sea water is 1.027). Compared with water from Lake Michigan, it contains relatively larger quantities of soda, potash, lime, magnesia, soluble silica, and chlorine. It also contains a small quantity of iron and aluminum. The following table gives a comparison of the more common mineral substances as found in Lake Amatitlan and Lake Michigan. The analysis of the water from Lake Michigan was made in office of Chicago Board of Health; that of Lake Amatitlan by Mr. R. Gwirz, in charge of the Government Chemical Laboratory of

Guatemala. From these analyses, the following table was prepared by Mr. Nichols, of this Museum:

	Parts per million.	
	L. Michigan.	L. Amatitlan.
Silica.....	5.00	40.00
Calcium Carbonate.....	50.00	140.00
Magnesium Carbonate.....	16.68	27.30
Calcium Sulphate.....	22.77	trace
Sod. & Pot. Chloride.....	14.75	210.00
Sod. & Pot. Carbonates.....	2.24	....
Ferric Oxide & Alumina.....	trace	6.00
Phosphates.....	....	trace
Potassium Nitrate.....	....	2.00
Nitrates.....	....	none
Ammonia.....	....	.02
Oxygen consumed —		
in acid sol.....	....	4.6
in alkaline sol.....	....	4.6
Total solids.....	111.40	421.00

It will be noticed that the total solids in the water of Lake Amatitlan is nearly four times that of Lake Michigan, although but about 1.2 per cent of that of sea water. The water of Lake Amatitlan, though considerably used by the residents for drinking purposes, is not a good potable water. It is slightly salty to the taste, and its oxygen consuming power indicates the presence of considerable decomposing organic matter, and consequently the probable presence of bacteria. It is probable that this test of the water was made some time after the water was taken from the lake, and is not a fair indication of its actual condition. By the residents of this region the lake water is regarded as poor for drinking purposes.

The amount of mineral matter in the lake is too small to unfit the water for fresh water fish life. The volume of water is large, and the inflow and the outflow great enough to prevent the lake water from ever becoming salty to any harmful extent.

The shore vegetation of the lake may be characterized as only moderately abundant. A few large trees, as the Willow (*Salix Humboldtiana*), and several species belonging to the genus *Ficus* (Rubber-trees) grow close to the water's edge, their low, drooping branches being often bathed by the waves. These trees afford a considerable amount of shade, which appears to be a favored hiding place for fishes in the lake. This, and other land vegetation, supports a large number of Fungi and Epiphytes (Orchids and Bromeliads) attractive to insects, which are constantly falling into the lake and forming a supply of food for fishes. There are no extensive forest areas on the



WILLOWS ON UPPER PORTION OF DELTA, LAKE AMATITLAN



UPPER END OF LAKE AMATITLAN

sides of the mountains immediately bordering the lake. The low flat area to the north and east is under cultivation. On it are grown sugar cane, lemons, oranges, and various other tropical fruits. The shrubs which grow close to the water's edge belong mostly to the Compositæ, and with these are usually associated many species of Lichens, Mosses, Hepatics, Ferns, and the like.

The flowering plants of the marshes are only moderately abundant along the shores of Lake Amatitlan, for there is very little low wet land along the margins, and very small areas of shallow water. The sudden great depth makes it quite impossible for the higher aquatic plants, particularly the marsh plants, to secure a foothold.

The most conspicuous of these marsh plants is a species of Cat-tail (*Typha angustifolia*), and a tall Rush (*Scirpus* sp.). These two species are recognized as Tules by the natives, who cut and dry them for weaving into mats. They usually grow together, and when this occurs one is generally much more abundant than the other. The Rush is the more abundant of the two in the deeper water. Neither of these grows where the water is more than five or six feet in depth, more than half of the plant being above the water. A small Spike Rush (*Eleocharis* sp.) is quite abundant along the shore next the lowland where sandy. It grows to a height of from one to eight inches, and is usually entirely submerged. It is at the base of these Cat-tails and Rushes that the larger Mojarras find their best breeding and spawning grounds, and where the fishermen find the capture of these fishes the easiest.

There are two species of grasses growing in patches along the shore of the lake. The larger one (*Panicum* sp.) is more common on the south side of the lake, more particularly where the margin is rocky. In general appearance it resembles sugar cane more than it does any other plant growing in the water of the lake, the other grass (*Phragmites* sp.) is widely distributed here, but is nowhere abundant. It occurs mostly on the side adjacent to the lowlands.

There are two floating plants which occur on the lake; the smaller (*Salvinia natans*) is the more widely distributed, being found in most places where there is other vegetation, and especially so in the neighborhood of warm springs. The larger of these floating plants is the Water Lettuce (*Pistia obcordata*), not found except along the shore next the low lands. It is abundant at only one plant, about one half mile above the railroad. The inhabitants call this plant La Chuga. It is easily distinguished from all other floating plants by its broad leaves growing in the form of rosettes.

There are several species of Pickerelweeds growing in the shallow

water where they can get a foothold. In most places, especially next the low lands, these plants are very abundant, usually growing to a depth of 20 feet or more. They are usually submerged, though occasionally the upper leaves or those in the shallow water float on the surface. Two species of these (*Potamogeton lucens* and *Potamogeton* sp.) are very abundant where found. Associated with these is a Hornwort (*Ceratophyllum demersum*), and two or three species of *Chara* are abundant. These submerged plants are very important in connection with fish food supply, since the absence of such plants means absence of the



WILD LETTUCE, LAKE AMATITLAN

small animals and insect larvæ, as well as a decrease in the quantity of algæ. The tender portions of these plants furnish a considerable supply of food for the smaller fishes in the lake.

There is in Lake Amatitlan a considerable quantity of microscopic organism, or Plankton, enough to prevent the water from being sufficiently clear to see a white object a foot in diameter deeper than 12 or 15 feet. The Phytoplankton here much exceeds the Zoöplankton; in Lake Atitlan the reverse is true. In general the Zoöplankton is dependent on Phytoplankton for its food supply. The Phytoplankton of Lake Amatitlan consists chiefly of algæ. Closely allied to but not properly included in Plankton are the larger forms of filamentous algæ. These are usually associated with the marsh plants and are often

attached to rocks, pieces of dead timber, sticks, and to the branches of trees which touch the water. The non-filamentous forms, or the blue-green slimes, are very abundant, and with many of these are associated filamentous forms. Some species grow in considerable quantities in very warm water near the warm springs. The most conspicuous and by far the most abundant of these blue-green forms is a species of *Clathrocystis*. It is exceedingly abundant near the surface in the upper half of the lake, or rather that portion above the railroad, but is not noticeable to the naked eye on that portion of the lake below the railroad. Associated with this form, in colonies, are several species of *Anacystis* and *Anabæna*. Belonging to these genera are the characteristic "Wasserblüte" plants, but these nowhere on the lake or near its margins formed a scum on the surface, and so, in the strict sense, "Wasserblüte" cannot be said to exist on the lake in January and February, especially so on its lower half; although, in a broader use of the term, the presence of *Anabæna* and *Clathrocystis* in such abundance indicated that it did exist to a limited extent, at least, on the upper half of the lake. "Wasserblüte" is considered by some writers to be injurious to fishes, especially so in small stagnant ponds. While this may be true in small ponds, it certainly is not in such large bodies of water as this lake, where the surface is frequently agitated. These forms do form a portion of the food supply of the fishes in this lake, and no doubt furnish the important food supply of *Entomostraca*.

The fact that the water in Lake Amatitlan has about the same temperature during the entire year would indicate that Plankton was quite uniform in quantity at all times; a condition which is not true, however, of our northern lakes.

In Lake Amatitlan the Phytoplankton is much more abundant in January and February than the Zoöplankton. In Lake Atitlan the reverse is true. Lake Atitlan, the larger lake, is about 1,000 feet higher. Its water will average from one to two degrees cooler than Lake Amatitlan. It has no outlet, and its drainage area is very small. That portion of Lake Amatitlan which is the least disturbed by the inflow and the outflow of water contains by far the greatest abundance of Phytoplankton.

The abundance of the blue-green algæ previously mentioned on one portion of lake, and not on the other, is not well understood. The only reason I am able to suggest why they are so much more abundant in the upper part of the lake than in the lower is that the drainage into this portion of the lake is small compared to that received by the lower portion. The upper part of the lake becomes

to some extent a body of partially stagnant water. In the lower portion there is a constant flowing in of a considerable amount of water at its upper portion, and a constant outflow at the opposite end. This would tend to decrease the quantity of any floating particles in the water. Much of the algæ floats on or near the surface. It is often driven together by the wind, forming on the surface of the lake large, blue-green patches. The algæ to which these species are most nearly related form a large portion of the food supply for microscopic animal life, and for small fishes which feed on vegetation. The Algæ and softer portions of the other water plants furnish a large part of the food supply for the young fishes, and also for the adult of the three most abundant species of fishes (Pescadito, Serica, and Mojarra) in the lake.

The water of Lake Atitlan is very clear as compared with that of Lake Amatitlan and, as noted above, the amount of Plankton material in it is very much less.

So far as I could discover there are no diseases among the fishes of Lake Amatitlan. The Mojarra are occasionally infested with intestinal parasites, but the fishes appear in good condition, which indicates that these do no harm. Parasites are occasionally noticed in the other species of fishes in the lake. Intestinal parasites are not uncommon with fishes and other animals, and their presence is not to be regarded as an indication of ill health or disease. In our northern waters there are occasionally epidemics among fishes during which many dead and dying are found along the shore. I was unable to learn of any similar epidemic among the fishes of Lake Amatitlan. If such ever occur they are not at all frequent or serious. During my stay at the lake all animal and plant life in the lake appeared vigorous and healthy. The uniform temperature of the water, the freedom from sewage, and the large volume of water, are all factors which induce a very healthful condition in this body of water. An over supply of plant life contributes largely to eliminate from the lake the noxious gases formed from any decomposition of animal or vegetable life, and to take up the waste products of water animals.

The conditions of Lake Amatitlan, its fish food supply, the temperature and purity of its water, etc., are such that it should contain a far greater number of large fishes than it does at present. In general, the fishes which feed on animal life are superior as food for man to those whose food consists mostly or entirely of plants; and it is this class of the larger fishes that is lacking in the lake. The smaller fishes, especially the Pescadito, are very abundant, and it seems best to introduce a few large species into the lake which would utilize these

for food. In this way a species of fish (the Serica), worthless as food for man, and another species (the Pescadito), too small to ever become a desirable food fish, could probably be converted into good food fishes.

In the Pacific Slope rivers of Guatemala there are no Mojarra which strictly feed on small fishes, and none larger or better than the one now found in the lake. The largest one (*Cichlasoma trimaculatum*) could easily be introduced into the lake. Its introduction would, to some extent, increase the food fish supply of the lake and its presence there would do no harm.

In the Rio Montagua and in Lake Isabel is a large Mojarra (*Cichlasoma motaguense*) which feeds mostly on small fishes. After the completion of the Guatemala Northern Railroad the introduction of this fish into the lake could be easily accomplished. It is a larger species than the Mojarra which now lives in the lake.

The Robalo (*Centropomus nigrescens*) and the Pepemechin (*Philypnus dormitor*) are food fish of some value. These are both found in the Pacific Coast streams of Guatemala. Concerning the value of these fishes as food or game fishes I know almost nothing. The Pepemechin is quite common in the lakes of Nicaragua, and is sold in the markets there for about the same price as is the Mojarra.

The Large-mouth Black Bass, which is found in all of the streams and lakes of the eastern United States, from Lake Superior to Tampico, Mexico, is a most excellent game and food fish. It feeds almost altogether on small fishes. Its flesh is firm and better flavored than that of any of the Mojarra or other fishes above mentioned. This fish is a great favorite with sportsmen, who fish with hook and line for pleasure. So highly prized is it in the United States, that it has been introduced into many of the western lakes and streams. The rate of growth of the Large-mouth Black Bass varies much in different localities. Individuals in some of our United States hatching stations are known to reach a weight of two to eleven pounds when two or three years of age. In lakes and streams in the southern United States this fish is often taken weighing 6 or 8 pounds, while individuals are not uncommon weighing 20 pounds or more. It grows larger and grows more rapidly in the waters of our southern states than farther north. In these southern waters it feeds during most of the year. During the winters in the northern portion of the United States the lakes and rivers become covered with ice, and the water in them under the ice is so cold that fishes become inactive and do not eat. So there is a period of from 2 to 4 months that fishes have no chance to grow. The water in Amatitlan is always warm enough to prevent this period of inactivity,

and so fishes will grow larger in a given time there than in the United States. In this respect there is a marked difference in the growth of the Large-mouth Black Bass in the lakes of Wisconsin and of Florida. The Large-mouth Black Bass spawns in the spring. It deposits its eggs in shallow nests which it makes near the shore in shallow water. Its habits in this respect are about the same as those of the Mojarra found in Lake Amatitlan.

Closely related to the Large-mouth Black Bass are the Rock Bass (*Ambloplites rupestris*), the Crappie (*Pomoxis sparoides*), and the Bluegill (*Lepomis pallidus*). These seldom exceed one or two pounds in weight. They feed on small fishes and afford much pleasure in their capture with hook and line. They are excellent food fishes. These fishes could easily be introduced with the Large-mouth Black Bass.

In the lakes of Nicaragua is a species of Mojarra known as Guapote (*Cichlasoma managuense*). In shape and form it much resembles the Large-mouth Black Bass of the United States. It grows to a length of 12 to 18 inches. This fish feeds upon smaller fishes. It is the best flavored food fish found in the lakes in Nicaragua. It will live out of water much longer than any of the fishes I have so far mentioned, which fact will greatly assist in its introduction into other waters than where found. Nothing is known of its spawning habits. Considering the temperature of the water (83° F.) in which it lives, its flesh is exceeding firm and well flavored. In the future stocking of tropical lakes with fishes, I am sure the Guapote should, and no doubt will, receive favorable consideration. In general, the fresh water fishes, when taken from cold water, have firmer flesh and are better flavored than those taken from warm water. In the northern lakes of the United States the temperature is seldom warmer than 60° F. Lake Amatitlan is 10° F. warmer. Owing to the fact that its volume of water is so great and its water so pure, it is probable that the Large-mouth Black Bass would not, to any marked degree, lose its good food qualities, and the Guapote would probably gain. There are several species of Catfishes which could easily be introduced at the same time.

The best fishes to introduce into Lake Amatitlan are the Large-mouth Black Bass (*Micropterus salmoides*), the Rock Bass (*Ambloplites rupestris*), the Crappie (*Pomoxis sparoides*), and the Bluegill (*Lepomis pallidus*). The second best fish seems to be the Guapote (*Cichlasoma managuense*) from the lakes of Nicaragua. The third choice would be the Mojarra (*Cichlasoma motaguense*) from Lake Isabel and the Montagua River. There could be no objection in introducing all of these fishes at the same time.

The habits of the Mojarras are not well-known, and their recom-

mended introduction into waters other than those in which they are now found is made with a little hesitancy. I am very sure that the introduction of those that I have named will do no harm, and the chances are that to introduce any or all of them will considerably increase the supply of food fish in the lake.

If quantity of fishes or of fish food, at the expense of quality, is desired, the German Carp is recommended.* The Carp is a large, coarse fish which grows very rapidly. It is also very prolific. A female of 25 pounds' weight, brought to the Museum a few weeks ago, contained about 1,750,000 eggs. This fish is much cultivated in small ponds in Germany, Austria and other European countries, and for small ponds they are much desired, for they grow more rapidly than do most of our better food fishes. At one year old, they weigh about one pound. At three or four years of age, they grow in ponds to a weight of 6 to 8 pounds. In large bodies of water they grow even more rapidly. In the Fox River, near Chicago, Carp are often taken of over 30 pounds weight. In the Illinois River more pounds of Carp are taken by commercial fishermen than of all other fishes combined. The Carp feeds upon plants, and of this class of food there is an abundance in Lake Amatitlan.

If Carp are introduced into the lake, it would not be so desirable to put into it the Large-mouth Black Bass, or the other fishes mentioned. In eating vegetation the Carp digs up the bottom, much as do hogs. In this way they might destroy spawning places for Mojarras, Large-mouth Black Bass, and other fishes, and the areas suitable for spawning places for these fish are small. In addition to this, they are sure to become abundant enough to stir mud and sand around the shores to the extent of making the water very muddy. In this way, the Carp would partially destroy some of the beauty of the lake.

In the introduction of the fishes mentioned the important thing to decide is whether first-class fishes are desired or not. If they are, the Carp should not be introduced into the lake. It is not nearly so good a food fish as is the Mojarra. If Carp are introduced, the supply of fishes for food will be many times as great as it is now, and perhaps twice as much as if the other species mentioned were introduced. The introduction of Carp is quite sure to decrease the abundance of better fishes, such as the Large-mouth Black Bass, the Crappie, the Rock Bass and the Guapote. For the introduction of any of the fishes mentioned, the food supply is abundant. The water is clear and pure, and the temperature is such that they would feed during the entire year, and thus grow rapidly.

* Mr. J. W. Ticomb strongly believes German Carp should not be introduced into this lake.

In order that fishes should exist in at least fairly large numbers, they should not be disturbed during the breeding season. The supply of fishes in Lake Amatitlan is much reduced in numbers by over fishing during the breeding season. Especially is this true of the Mojarras. This fish deposits its eggs in nests made by it in the sand at the base of the Tules. When depositing their eggs, the fishes are very persistent



FISHERMEN, LAKE AMATITLAN

in remaining in shallow water along the shore, and so at that time they are more easily caught. In catching them by the methods used by the lake fishermen many of the nests are destroyed, and the chances for increase are much reduced. During the breeding time of food fishes a portion or all of their spawning grounds should be protected. The fishes at the breeding time are not so good to eat as at other times of the year. Another bad feature in the taking of Mojarras is the capture of such a large number of small individuals. The smaller

ones should not be taken from the lake. In one or two years they would grow into large fish and be more desirable. The German Carp is about the only species of fish that will increase rapidly no matter when, or where, or how caught. All other species should be protected and cared for during the breeding season; and the small ones, those less than $\frac{1}{4}$ or $\frac{1}{2}$ grown, should not be taken from the lake, but if caught should be returned immediately to the water. The spawning time of the Mojarras and the Large-mouth Black Bass is in the spring — the most of it during April, May, and June. If the laws regarding fishing in Lake Amatitlan were as strict as they are in the lakes of Illinois, Indiana, and others, of our northern states, the Mojarras there would greatly increase in numbers. The Carp need no protection, and where the volume of water is as great as it is in Lake Amatitlan, they are quite sure, if introduced, to always be plentiful. Personally, I should advise that Carp be not introduced into the lake.

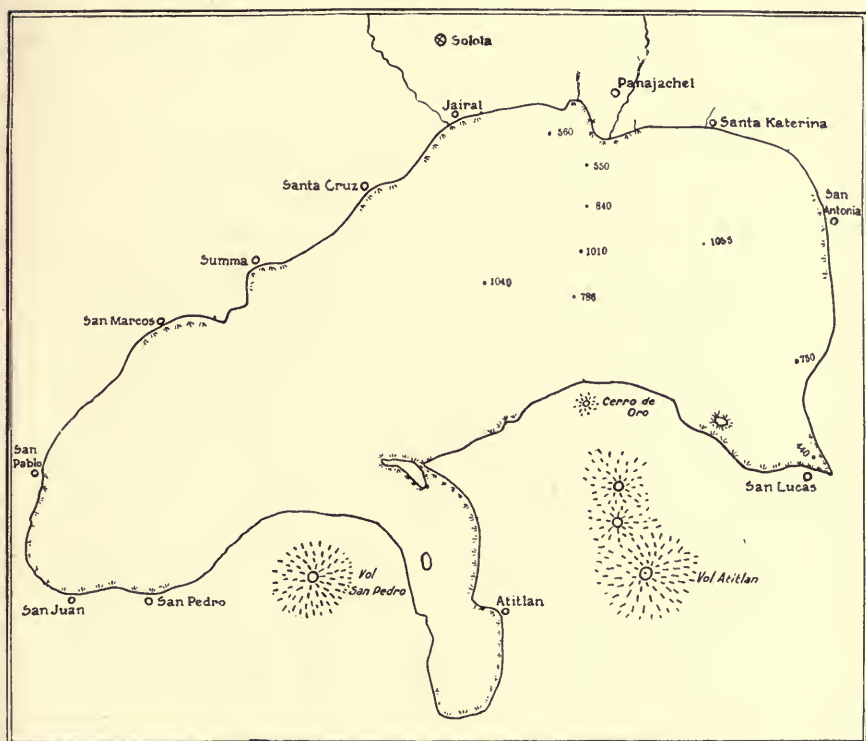
During a portion of January and February a maximum and minimum self-registering thermometer was exposed at Laguna with the following results. The coldest time of the day was between 3 and 5 A. M. The warmest was between 2 and 4 P. M.

January 17, coldest 66° F. warmest 75° F.			
"	18,	"	65° " " 76° "
"	19,	"	65° " " 76° "
"	20,	"	61° " " 74° "
"	21,	"	60° " " 74° "
"	22,	"	62° " " 79° "
"	23,	"	56° " " 70° "
"	24,	"	56° " " 67° "
"	25,	"	55° " " 66° "
"	26,	"	55° " " 64° "
"	27,	"	56° " " 66° "
"	28,	"	53° " " 65° "
"	30,	"	58° " " 69° "
"	31,	"	61° " " 69° "
February 1,	"	59° " " 72° "	

LAKE ATITLAN.

Lake Atitlan is a mountain lake, whose elevation is about 5,000 feet above the sea. Except for the narrow pass to the south, through which one passes on the road between San Lucas and Patulul, the lake is surrounded by mountains, which rise directly from the water's edge to an elevation of about 2,500 feet above its surface. There are several small streams flowing into the lake. The largest one empties

into the lake near the village of Jairal; the next largest near Panajachel. The valleys drained by these streams are each about one mile wide and two or three miles in length. So small are all of these valleys that the shore of the lake has been but very slightly changed since its formation. The lake has no visible outlet. If it ever had one it was through the San Lucas pass. On the south shore of the lake are two volcanoes, Atitlan and San Pedro, whose summits are 7,000 feet above



LAKE ATITLAN SHOWING DEPTH WHERE SOUNDINGS WERE TAKEN

the lake and 12,000 feet above the level of the sea. To the north and back of the mountains bordering this side of the lake, is the plateau over which the upland road between Guatemala City and Quezaltango passes. This plateau is about 5,000 feet above the lake.

Lake Atitlan is about 12 miles wide and about 24 miles in length. It is one of the most beautiful of our American lakes, and is situated in a most delightful and healthful climate. Its elevation, and the scarcity of lowland and swampy places, unfit it as a habitation for mosquitoes, and so it is always free from malarial fevers.

Along the greater part of the shore line the mountains rise perpendicularly out of the water, and so within a few feet of the water's edge the depth is very great. At almost any point along the shore from San Lucas to Santa Cruz (the only shore where soundings were made near the water's edge) the lake less than $\frac{1}{4}$ mile from shore is between 400 and 700 feet in depth; near the middle of the eastern half of the lake its depth is over 1,000 feet. The deepest place found by me was 1,055 feet, which is probably the deepest place in the lake.

The water in the lake is exceedingly clear. A white disc 12 inches in diameter can easily be seen at a depth of 45 feet. The shallow water near the shore is confined to the small stretches at the mouth of the few small inlets, and to the shore to the north of Atitlan and west of San Lucas. The margins of these areas usually support a growth of Tules such as are found in Lake Amatitlan. In these limited areas, water plants, as *Chara*, *Potamogeton*, and *Algæ*, are abundant.

Of microscopical animal and plant life there is less to a cubic foot of water in Lake Atitlan than in Amatitlan. As compared with its immense volume of water the shore vegetation is very small and the spawning and feeding grounds for fishes are very much reduced.

The temperature of the water in Atitlan is 68 degrees. The surface during warm days becomes slightly warmer to a depth of about 5 feet. Below 5 or 10 feet the temperature of the water in the lake is 68° F. I was unable to take the temperature deeper than 750 feet, but wherever taken the temperature was the same. There are two small streams flowing into the lake near Panajachel. Between 3:30 and 5:30 P.M. on February 19, the temperature of the water in both of these streams near the lake was 64° F.

In Lake Atitlan there are but three species of fishes, all of which are natives of Lake Amatitlan. The largest is the Serica (*Cichlasoma nigrofasciatum*); the most abundant is the Pescadito (*Pacilia sphenops*), and by far the least important is the Gulumina (*Fundulus guatemalensis*). These fishes are much used for food by the natives, especially by those people living in Santa Catalina. These fishes are eaten only because no others are to be had. An effort is being made to introduce into this lake fishes from the rivers of the lowland. Already two or three species of Mojarra and the Pepemechin have been brought up from the lowlands and placed in a pond near San Lucas. It is very doubtful if much benefit will be derived from this effort to stock the lake, but certainly no harm can result from it. The same energy, more wisely applied, might result in more good.

This effort is an experiment, with chances in favor of increasing and improving, to a very limited extent, the fishes in the lake.

The conditions for introduction of fishes into Atitlan are much different from those existing in Lake Amatitlan. Atitlan is very deep, with but a small amount of shallow water for spawning and feeding grounds. It is very certain that Lake Atitlan cannot support nearly so many fishes per cubic meter of water as can Lake Amatitlan. Its volume of water being many times greater, the capture of the fishes would be much more difficult. The stocking of this lake for strictly commercial purposes is sure to result in disappointment.



LAKE ATITLAN NEAR PANAJACHEL

The fact that Lake Atitlan is such a beautiful sheet of water, situated at an altitude, and so completely surrounded by mountains as to insure it a delightful and healthful climate, is quite sure to cause it to become a resort for many people living in the cities and in the lowlands of Guatemala. There is nothing that would add more to the attractiveness of this place than to have in the lake a fair supply of first-class game fishes,— that is, fishes whose capture with hook and line would afford recreation and pleasure. Fishes of this sort, which are commonly known as game fishes, are the only ones that should be introduced into this lake. Of all fishes the Carp should be avoided. The vegetation about the lake is too scant to ever enable this fish to become abundant

enough to be of commercial value. The difficulty of taking it, or any large fishes, from the lake with nets would be so great as to make fishing for them for commercial purposes unprofitable.

The water in Lake Atitlan is cool enough and pure enough to justify the introduction of Rainbow Trout (*Salmo irideus*). This is a very beautiful fish, a very excellent food fish, and one very popular with the professional sportsman who fishes for pleasure with hook and line. It is one of the very best American game fishes. This fish grows to a weight of 10 to 12 pounds in comparatively warm water, the average weight being from 3 to 6 pounds. In very cool water the growth is slow, and the fishes may never exceed one or two pounds in weight. The introduction of the Rainbow Trout is very simple and easy, if care is taken. The eggs can be obtained at hatching stations operated by the United States Bureau of Fisheries, packed in ice and shipped to the lake, and there hatched. After trout eggs have been hatched until the eyes appear as dark spots, their development can be arrested by packing them in moss on trays which are surrounded by ice. Eggs packed in this way have been sent to Europe, Argentina, South America, and to New Zealand, and they could easily be taken in this way to Lake Atitlan. The small streams which flow into the lake would furnish a limited spawning area, but the supply of fishes could easily be increased by the addition of a small hatching station on one of the streams. The artificial propagation of trout presents no serious difficulties. Any intelligent person who is careful can, with a little training, successfully operate one of these stations. The Rainbow Trout is a fish which quite readily adapts itself to surrounding conditions. Its natural habitat is in water cooler than that found in Lake Atitlan. It is known to live in water as warm as 75° F. and it is very certain that it will do well in a large body of pure water, such as we find in the lake in question.

In addition to the introduction of Rainbow Trout, the Steelhead Trout (*Salmo gairdneri*) and the Landlocked Salmon (*Salmo sebago*) are recommended. These fishes grow larger than do the Rainbow Trout, and their eggs can be transported and hatched in the same way. The Trout and Salmon are much more easily introduced into the lake than are any others, and they are far more desirable.

The next desirable fishes to introduce into Lake Atitlan are the Large-mouth Black Bass, the Rock Bass and the Crappie. These fishes would probably do well in the lake, but they should not be introduced if any or all of the species mentioned above are put into the lake. No species of fishes will ever become abundant in this body of

water, because the spawning and feeding grounds are so small, when compared with the immense volume of water in the lake.

Lake Atitlan will always be attractive to the pleasure seeker, if it contains game fishes like the Rainbow Trout or the Large-mouth Black Bass. The money brought to its shores by the pleasure-seeker will, no doubt, be greater than could be realized from the capture and sale of German Carp if introduced there, for this lake is not suited for Carp, and its introduction into this lake should not be considered. The food supply is not at all large, and the great depth of the water would render the capture of the Carp very difficult. Carp should never be introduced into Lake Atitlan.

The Rainbow Trout, the Steelhead, and the Landlocked Salmon are the most favored fish for this lake. If these fishes are not selected, the next best are the Large-mouth Black Bass, the Crappie, the Rock Bass, and the Bluegill.

THE FISHES OF LAKES AMATITLAN AND ATITLAN.

The fish fauna of these lakes is not extensive. In Lake Amatitlan occur seven species, only three of which, the smallest ones, are found in Lake Atitlan. Of those in Lake Amatitlan only three exceed a length of four or five inches, and two of these are very slender, which really leaves but one species which, if in the United States, would be considered of sufficient size to become a marketable fish. This largest species is not plentiful, due largely no doubt, to over fishing. For catching the smaller species, the ordinary cast or throw net is used. These nets vary in size from about four feet to about ten feet in diameter. The mesh is about $\frac{1}{2}$ inch stretch measure. The larger Mojarras are taken with gill nets, which are usually about six feet in depth and about 100 to 300 feet in length, with a mesh of about $1\frac{1}{4}$ inches, stretch measure.

Family **Siluridæ**. CATFISHES; BAGRES; JULINS.

Rhamdia cabreræ Meek. JULIN.

This fish inhabits the lake, though it is more abundant in the outlet. Its food consists almost entirely of insects and insect larvæ. The stomachs of most of those examined by me contained almost entirely the larvæ of the mosquito and the damselfly. The Julin seldom reaches a length of over 200 mm. It is

very slender, and so one that is full grown is not large. As a fish for food for man, or for food for other fishes, it is of very little importance. It is reported to spawn during the months of March, April and May. Lake Amatitlan, scarce.

Family **Gymnotidæ.** EELS.

Gymnotus carapo Linnæus. ANGUILLA.

This fish reaches a length of about 210 mm. It is very slender. During my stay at the lake I saw but three specimens of this species, and was unable to learn much about its habits. I was told that it is only occasionally taken in the lake, and though it is much prized as a food fish, it is too small, and found in too few numbers, to be of any economic value. This fish inhabits streams from Lake Amatitlan and Rio Motagua to the Rio de la Plata in South America. Lake Amatitlan, scarce.

Family **Characinidæ.** CHARACINS.

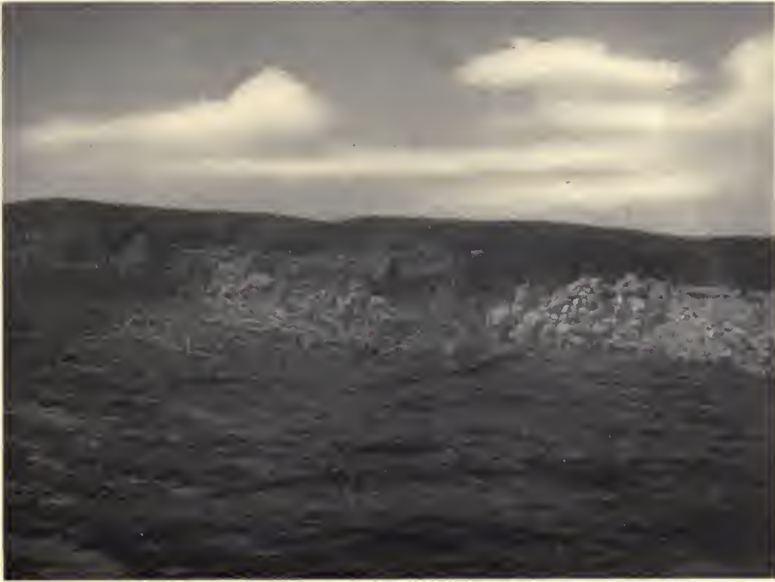
Astyanax microphthalmus Günther. PEPESCA.

This fish reaches a length of about 140 mm. It is a deep fish of silvery color, with a dark band on the posterior half of the middle of the body. The food of this fish consists almost wholly of insects and insect larvæ. These fishes usually go to deep water in the daytime and so seldom are fished for except at night. They are most abundant in the inlets and near the outlet of the lake. The Pepescas are sold in large numbers in the markets at Amatitlan. They spawn about May, probably April, May and June. I could secure no information in regard to their spawning habits. This fish is too small, and is found in quantities not large enough to be of much economic value. Lake Amatitlan, common.

Family **Poeciliidæ.** KILLIFISHES.

Fundulus guatemalensis Günther. GULUMINA.

The Gulumina is a small, nearly cylindrical fish which grows to a length of about 85 mm. It is more abundant in the outlet of the lake than in the lake itself. This fish is seldom taken in shallow water along the shores where the Pescaditos are most



FISH TRAP. LAKE AMATITLAN



FISH TRAP, LAKE AMATITLAN

abundant. I examined many large catches of the latter and did not find in them a single species of *Gulumina*. I observed this small fish to be exceedingly abundant along the railroad fill. During warm days, when the sun was shining brightly, they would rise in large schools near the surface of the water. On coming near the water's edge, or approaching them slowly in a boat, they would sink to a considerable depth and hide among the rocks. The food of this fish consists almost entirely of insects and insect larvæ. It is said to spawn about March and April. Lakes Amatitlan and Atitlan, scarce.

***Pœcilia sphenops* C. & V. PESCADITO.**

There are probably more individuals of this fish in Lake Amatitlan than of all other fishes combined. It is a small fish, in shape and size much like the *Gulumina*. This fish is viviparous; that is, it brings forth its young alive. Each female has a brood of from 30 to 50 small fishes. The young are born in March and April and May. This fish feeds on filamentous algæ, the larger species of free algæ, and the tender parts of the *Chara*, *Potamogeton* and *Ceratophyllum*. They also eat mud in which microscopic animal and plant life is abundant, and also insects and insect larvæ when these are abundant. This species comes near shore in greater numbers during the night, yet they seem very plentiful in daytime in shallow water. They are caught in large quantities by the residents of this region. Their flesh is quite firm and well flavored, but the many small bones and their small size prevent them from being very desirable for food. The absence of better fish, or the presence of no fish at all, and the ease with which they can be taken in large numbers, largely explains why so many are used for food by residents about the lakes. These fishes are captured by the small-mesh throw-nets used so extensively in Spanish American countries. In order to make their capture more certain and easy, the fishermen build nearly circular basins along the margins of the lake. These basins are formed by placing rocks around the margin, enclosing areas of shallow water usually about one or two feet deep and from 5 to 15 or 20 feet in diameter. These are often built in the shade of an overhanging bush, or they may or may not be covered with brush. On the side towards the lake a narrow opening is left through which these small fishes enter the basin. In a short time the Pescaditos enter these basins in large numbers. After



FISH RUNWAYS, SANTA CATARINA. LAKE ATITLAN



CATCHING SERICAS LAKE ATITLAN

they have become accustomed to these places, the fisherman removes the brush and the fish continue to enter the enclosure the same as before. When the net is thrown into the center of the enclosure, the fish become frightened and swim in all directions. By the time the net strikes the water they have gone to the edges of the basin, and not being able to escape swim back towards the opposite side and thus many are caught under the net. A few throws take most of the fish out of the basin. Soon, however, others come in and are captured in the same way. The Pescaditos frequent the shore and these basins in larger numbers at night than in the daytime, and so fishing for them is done mostly after sundown. In rocky places, and where there is no shallow water, these basins are made by digging back in the shore, and some have been made at the expense of considerable labor. These small fishes are usually more abundant along the shores where there are warm springs. On Lake Atitlan, at Santa Catarina, is a stretch of shore line where there is considerable surface of warm water. At this place narrow trenches are dug back some distance, which this species frequents in large numbers, where they are easily caught. The shore of this lake contains only small areas of shallow water, and does not afford opportunities for the construction of small trap-like basins for the capture of this fish, as does the shore at Lake Amatitlan. Conical traps, made of wickerwork, are also used here to capture these fishes. The Serica is, however, more easily taken in these traps than is this species. In these lakes and neighboring waters there are evidently more individuals of the Pescadito than of all other fishes combined. This is especially true of Lake Atitlan. This species is very abundant in fresh and brackish water of the lowlands of southern Mexico, south to Nicaragua. In Central America it is the small fish found near the head waters of rivers on both sides of the divide. It is the small fish usually seen swimming near the hot springs in Middle America. It probably never goes in water warmer than 100 to 110° F. It certainly does not at Amatitlan. As food for game fishes, it will serve its purpose best. The introduction of a fish which lives on small fishes is the best means of converting this species into much better food than it at present makes. Lakes Amatitlan and Atitlan, very abundant.

Family **Cichlidæ**. MOJARRAS.**Cichlasoma nigrofasciatum** Günther. SERICA.

Next to the Pescadito, the Serica is most abundant in the lakes. It is a small Mojarra never growing longer than 100 mm. As a food fish it is considered of little value by the people who live on Lake Amatitlan. The chief objection to it is its small size and the numerous small bones it contains. This fish is not seen in the markets and seldom in the catch of any of the fishermen there. It is very abundant along the shores where there is much vegetation, as it feeds almost entirely on algæ and the tender parts of the higher water plants in the lakes. It is a handsome, active fish, but of no important commercial value. This fish in Lake Atitlan is of more importance, due largely to the absence of larger fishes. It is easily captured by use of conical wickerwork traps, which are set in the water where vegetation is abundant. The Serica will enter fish traps of this style in Lake Amatitlan in far greater numbers than do any of the other species there. Its habits, so far as known, are about the same as those of the Mojarra. They deposit their eggs in April, May and June. So far as known, this fish is found only in the mountain lakes of western Guatemala, but it is not, at present, recorded from any of the rivers of the Republic. Lakes Amatitlan and Atitlan, abundant.

Cichlasoma guttulatum Günther. MOJARRA.

This is the largest fish in Lake Amatitlan. The largest specimen obtained by me was 270 mm. in length. It is a very handsome fish; its flesh is well flavored and very firm. As a food fish it is regarded as one of the very best in the fresh waters of the republic. This fish feeds to some extent on small fishes, but plants formed much the largest supply of the food of a large number of specimens examined by me. The Mojarra deposits its eggs in nests made in the sand and gravel in shallow water at the base of the Tules. I am told that they deposit their eggs in April, May and June. This fish is found in the rivers on the west slope of Guatemala. Its rather small size, and being found in rather small numbers, prevent its becoming a food fish of much importance. Over fishing, especially during the breeding season, is always sure to keep the numbers of this fish much reduced in the lake. All of the individuals of the species which are caught, whether large or small, are used for food. These fishes are

usually taken in gill nets. These nets are about one to 300 feet in length and about 6 feet in depth. A net is run out for about $\frac{2}{3}$ of its length along the edge of the Tules; the ends are carried at right angles into the Tules, forming three sides of a rectangular enclosure. The fishermen then get between the shore and the net, and drive the fishes with considerable vigor towards the net. They appear to be easily gilled. The net is then taken up and put out as a seine into the deeper water just outside the line of the Tules, in the form of a circle. The boat is anchored to the Tules,



FISHING FOR MOJARRAS, LAKE AMATITLAN

the ends of the net are drawn to the boat, and the circle closed by lapping the ends of the net. The fishermen slowly pull in the net by the cork line, permitting it to gather in folds at each end of the boat. Usually several fishes are gilled in this way, and are taken out as the net is pulled in. The fishermen then move to another place and repeat these hauls till a sufficient number of fishes are taken. This species of fish is usually taken in daytime. It is said that at night they go into deep water. The largest numbers are taken during the months when they are breeding, for during this time they are more easily caught. The practices of the fishermen on Lake Amatitlan in taking this fish at all times of the year are very harmful to their own interests, and would not be tolerated on

any lake or stream in the United States. These fish should not be disturbed when they are depositing their eggs, and at other times of the year only the larger ones captured should be retained, and all others returned to the lake. Lake Amatitlan, common.

AMPHIBIANS OF LAKES AMATITLAN AND ATITLAN.

One toad and three frogs are the only Amphibians taken at these lakes. During the winter and the dry season these animals are not abundant in the tropics, and the following list is not a fair index of their abundance in these places. The larger frog, *Rana pipiens*, is the only one used for food by the natives. It occurs at both lakes. For assistance in the identification of these species I am indebted to Dr. L. Stejneger, Smithsonian Institution, Washington, D. C.

Family **Bufonidæ**. TOADS; SAPOS.

Bufo marinus Linnæus. TOAD; SAPO.

Several toads inhabit Guatemala, but this is the only species I found on the shores of Lake Amatitlan. This species deposits its eggs in shallow water, and there they develop into the larval or tadpole stage. In this stage they feed chiefly on algæ. Although many of them are eaten by fishes they are not abundant enough to furnish any large supply of food for fishes. This toad is very abundant in the West Indies, and from southern Mexico to Brazil. It is one of the largest toads in Middle America. Abundant on shores of Lake Amatitlan, but it does not occur at Lake Atitlan.

Family **Ranidæ**. FROGS; RANAS.

Rana pipiens Gmelin. FROGS; RANA.

This is the larger of the two frogs found in this region. It is found in wet places and in shallow water, along the shores of both lakes. Its feet are webbed, a character which distinguishes it from the species listed below. It deposits its eggs in shallow

water, and these develop into a larval or tadpole form, which much resembles that of toads, and which has similar habits. The tadpole or larval form of the frog is larger than that of the toad, though the adult is smaller. Lakes Amatitlan and Atitlan, common.

Family **Cystignathidae**. FROGS; RANAS.

Leptodactylus microtis Cope. FROG; RANA.

This small frog is quite abundant in wet places under stones, pieces of wood or other material, which easily conceal them. Its breeding habits are the same as those of the preceding species. Though quite abundant about the shores of the lake Amatitlan it is too small to be of much economic importance. The adult frog and the adult toad feed mostly on insects. This species was not taken at Lake Atitlan. Common at Lake Amatitlan.

THE REPTILES OF LAKES AMATITLAN AND ATITLAN

Reptiles were not abundant during January and February on or about the shores of these lakes, and none of those found there, except one turtle, are distinctively water animals. The following list comprises all that were taken or were common near the water's edge. No water snakes, or rather snakes frequenting the water, were observed during my stay at these lakes.

Family **Iguanidae**. IGUANAN.

Basaliscus vittatus Gray.

A few specimens of this species were taken along the more rocky shores of Lake Amatitlan. It is not nearly so abundant here as in the lower lands.

Iguana rhinopla Gray. IGUANA.

One specimen was taken during my stay at Lake Amatitlan, the only one I saw.

Ctenosaura acanthura Gray. IGUANA.

This species is very abundant along the rocky shores of the lake. Its eggs and flesh are eaten by the natives. This species

and the two preceding apparently do not occur on the shores of Lake Atitlan. This lizard is very abundant along streams in the lower lands of western Guatemala.

Family **Teiidae**.

Ameiva undulata Gray.

This small lizard is quite plentiful on the shores of both of these lakes. It seldom, if ever, enters the water, and is too small to be of any economic value.

Family **Cinosteridae**. TURTLES.

Cinosternum cruentatum Dumeril. TURTLE; TORTUGA.

The only turtle I saw at Lake Amatitlan was an individual of this species which I purchased of a native at Laguna. So far as I could learn, turtles are very scarce in this region. The specimen here listed agrees well with the accounts of the species as given by Dr. Günther and Dr. Boulenger. Length of carapace 122 mm., width, 85 mm., depth, 62 mm.; length of anterior lobe of plastron 42 mm., of middle lobe 27 mm., of posterior lobe 45 mm.; posterior margin of plastron with a slight notch.

The members of the family to which this species belongs are regarded as inferior for food. The introduction of one or more turtles would increase the food supply of the lake, and in no way be harmful to the fishes now there, or to the fishes introduced.

THE WATER BIRDS OF LAKES AMATITLAN AND ATITLAN.

The following list of water birds includes only such species as were collected, by Mr. Barber or by Dr. Dearborn, or positively identified by other means, during a brief visit to these lakes in March and April, 1906. It may be well to state in this connection that both of these lakes are centers for all bird life, at least during the dry season, when the surrounding mountains are without green vegetation, and the short alluvial valleys alone furnish green foliage and food for all classes of birds. Most of the species here named are undoubtedly to be found in this region only in

winter, as their breeding range is much to the northward of Guatemala. This account of the water birds of this region was kindly furnished me by Dr. Ned Dearborn* of this museum.

Family **Podicipedidæ**. GREBES.

Colymbus dominicus brachypterus Chapman. SHORT-WINGED GREBE.

A small colony of Short-winged Grebes frequented an area of surface vegetation in a small bay of Atitlan near Panajachel, whence several specimens were collected in April.

Colymbus nigricollis californicus Heermann. AMERICAN EARED GREBE.

American Eared Grebes were found in small numbers at the western end of Amatitlan, and more common and generally distributed near Panajachel on Atitlan. At this latter place, the Indians, by dextrous paddling in small canoes, tire out and capture these Grebes after a short but lively chase. The Grebes, as well as all the other species of water birds, remain near the shore when undisturbed, as the rapidly declining bottom of the lakes allows them only a narrow margin to feed upon.

Family **Anatidæ**. DUCKS.

Querquedula discors Linnæus. BLUE-WINGED TEAL.

One specimen of Blue-winged Teal, taken on Atitlan by Mr. Barber in February, was the only duck encountered that could be identified. A flock of several hundred ducks was seen at Amatitlan, but they were so wild that it was impossible to approach near enough to make out what they were. The same uncertainty prevailed with regard to a few other ducks at Atitlan.

Family **Ardeidæ**. HERONS.

Butorides virescens Linnæus. GREEN HERON.

Green Herons were found scatteringly in all parts of the

*For an account of the birds collected on this Expedition, see Publication 125 Field Mus. Nat. Hist., Ornithological Series, Vol. 1, No. 3, 69 to 138, 1907.

Republic that were visited. In the collection made by Mr. Barber at Atitlan is one specimen.

Family **Rallidæ.** RAILS; COOTS.

Porzana carolina Linnæus. CAROLINA RAIL.

Carolina Rails winter sparingly about the shores of both these lakes, specimens being taken at each of them. They follow the fringe of tules wherein are food and seclusion.

Gallinule galeata Lichtenstein. FLORIDA GALLINULE.

A single Florida Gallinule, the only one observed, was taken at Amatitlan in February. It was living in a patch of tules adjacent to a hot spring.

Fulica americana Gmelin. COOT.

Coots winter abundantly at both lakes. They procure most of their food by diving, a short distance out from shore, though they feed more or less in the strip of tules that fringes the water's edge. They dive without difficulty, notwithstanding the fact that when they come to the surface to breathe and swallow, they come up as buoyantly as pieces of cork. Coots are captured by the native boatmen at Atitlan in the same manner as Grebes are, that is to say,—by running down, when a blow from a paddle quickly ends the chase. This mode of pursuit was observed frequently at Atitlan by both Dr. Meek and Mr. Barber, but at Amatitlan the gun was the only weapon used against any sort of water-fowl.

Family **Scolopacidæ.** SNIPES.

Gallinago delicata Ord. WILSON'S SNIBE.

Several Wilson's Snipe were seen at Atitlan in March by Mr. Barber.

Acititis macularius Linnæus. SPOTTED SANDPIPERS.

A few Spotted Sandpipers winter in this region. One was seen at Amatitlan and two were secured at Atitlan.

Family **Charadriidæ.** PLOVERS.**Oxyechus vociferus** Linnæus. KILLDEER.

The Killdeer winters in some parts of Guatemala — notably along the Motagua River — in considerable numbers. One was observed at Atitlan on April 9th.

Family **Alcedinidæ.** KINGFISHERS.**Ceryle alcyon** Linnæus. BELTED KINGFISHER.

Belted Kingfishers were not uncommon at Atitlan, where several were seen and one taken. One was seen at Amatitlan.

Ceryle americana septentrionalis Sharpe. TEXAS KINGFISHER.

Texas Kingfishers were found at both lakes, but more commonly at Atitlan, where two specimens were secured.

THE ZOÖPLANKTON OF LAKES AMATITLAN AND ATITLAN.

The lowest forms of microscopic animals found in these lakes are treated under this head. They do not occur in any very great abundance and the number of species is small. The following account of these forms was kindly furnished me by Mr. H. Walton Clark, Assistant, U. S. Bureau of Fisheries, Washington, D. C.

Family **Volvocidæ.****Cœlastrum microporum** Nägeli.

Not uncommon. A few specimens were found scattered through samples No. 19 (Feb. 5th, Amatitlan, towing made at noon from bottom to top in 110 feet water) and No. 20 (Jan. 17th, Lake Amatitlan, in front of hotel). None of the specimens showed the tubercles on the cells shown in many illustrations, but according to descriptions and a few figures, these may be absent. One colony appeared to possess eye-spots, one in each cell. One colony examined measured 60 μ . diameter, cells 15 μ ; full grown col-

onies are said to attain a diameter of 40–100 μ ., and individual cells as much as 25 μ .

Eudorina stagnale Wolle.

This is one of the common elements of the plankton, occurring in the greater number of samples, never in great abundance, but usually several, and often numerous examples could be seen in the field at the same time. It was quite frequently found in stages of active division.

I have not had opportunity to compare carefully Wolle's description of *Eudorina stagnale* with the description of the European form, *elegans* Schmidle. In a recent article on Algae from Brazil, he identifies the *Eudorina* found there as *elegans*.

Family **Peridiniidæ.**

Peridinium tabulatum Ehrenberg.

Common in most of the plankton, abundant in a good deal of it. The form at hand is that with the cleft anterior portion; diameter of a specimen measured, 65 μ . Griffith and Henfrey give the length as 1–480'', which reduces to 52 μ . All our examples appear to be of nearly uniform size. They are exceedingly abundant in sample 8, collected at the west end of Lake Amatitlan, on the surface. This catch consisted mostly of insect exuviae, and it is remarkable that the greater number of the Peridiniums were crowded densely in the cast-off skins, as if they had worked their way in for food or shelter.

Peridinium hirundinella O. F. Muller.

Rather common; scattered through most of the phytoplankton from Lake Amatitlan, and also in the Atitlan material. Our specimens agree very well with the figures found in Kent, and in the figures in the Riverside Natural History. All are robust and quite rough.

This species is almost cosmopolitan, having been reported from England, India (Kent), the Great Lakes (Riverside Nat. Hist.), and from lakes in Iceland (Ostenfold). (I have so far found none in Lake McDonald, Alaska, though there are several other species represented.) Apstein (l. c.) notes slender 3-horned specimens as occurring in the Dorbesdorfer Sea. All the exam-

ples seen from Lake Atitlan were 4-horned, but many, perhaps the majority, from Lake Amatitlan, were 3-horned. They did not appear to be more slender than the others, however. Kent gives the size as "Length 1-120" to 1-90"—208 μ to 277 μ ." The examples at hand measured 220 μ long, and 70 μ wide at the broadest portion of the body.

SPONGE IN LAKE AMATITLAN.

Family **Spongilidæ**. FRESH-WATER SPONGES.

Spongilla fragilis Leidy. FRESH-WATER SPONGE.

So far as I was able to discover, there is but one species of Fresh-water Sponge in Lake Amatitlan (none was observed in Lake Atitlan). This sponge is not very abundant, and is usually found growing on rocks or pieces of wood in the water. It appears on these objects usually as light brown patches, although its color may vary from nearly white to a bright green. The shade of color depends much on the amount of light. The lighter shades are found in the darkest places, and the green color in bright sunlight.

In general, this sponge bears some resemblance to our commercial sponges which grow in the sea. The important difference between those in salt-water and fresh-water is in the composition of the spicules—the harder skeleton mass. The spicules of the salt-water forms are made up of a horny elastic fibre, while those of fresh water are composed of silica.

The patches of sponges found on rocks along the shore of Lake Amatitlan are subcircular, being thin at the edges and thicker in the middle.

This sponge is not abundant and is of no commercial value. It is apparently of no economic importance, so far as the fish supply of the lake is concerned.

This species is very widely distributed over North America, but is not known from bodies of water farther south than Lake Amatitlan. For the identification of this species, I am indebted to Dr. Edward Potts, of Philadelphia.

THE LEECHES OF LAKE AMATITLAN.

By J. PERCY MOORE.*

Family **Glossiphoniidæ**. SNAIL LEECHES.**Glossophonia lineata** (Verrill).

This little leech was originally described from Nebraska and Florida. It is now known to range very extensively over the Pacific side of South America, through Central America, Mexico, the entire United States, and into the southern half of Canada, and is carried from place to place attached to the feet of migrating water birds. Several specimens were taken, in association with *E. triannularis*, under stones in Lake Amatitlan.

Although presenting many varieties, a general characteristic of the species is the double line of small conical papilla along the middle of the back. The striking color pattern of brown and white in vivid contrast is also limited to this and one other species of the genus.

Besides seeking concealment beneath stones and leaves in the water, it attaches itself to the bodies of snails, frogs and larger leeches, upon the first of which, as well as upon small worms and insects, it subsists. In common with other members of the genus it bears its eggs and young on the ventral surface, protected by the inrolled margins, and supplied with currents of fresh water by the rythmic undulations of the body. When disturbed, it rolls into a ball and remains for a time quiescent.

Family **Erpobdellidæ**. WORM LEECHES.**Erpobdella triannulata** Sp. nov.

Form moderately slender, width greatest at caudal end of clitellum, thence nearly uniform, but tapering gently to caudal end; subterete in pre-clitellar region, moderately depressed, and

*Two species of Leeches were found in Lake Amatitlan, but none was taken in Lake Atitlan, as no special search was made for them there. These leeches are small, and one, or both, species is quite abundant under stones. The small size of these animals, and the fact that they are hidden, render them of little if any economic importance. The account here given of these leeches was prepared for this paper by Dr. J. Percy Moore, of the University of Pennsylvania.—[S. E. M.]

in cross-section elliptical in post-clitellar part; lateral margins rounded except near the caudal sucker, where thin lateral wings extend for a short distance.

Mouth moderate, the upper lip rather short and broad and moderately furrowed. Eyes 3 pairs, the first much the largest and most conspicuous, situated in the dorsum of somite II, the other two pairs equal and situated one above the other at the sides of the mouth on somite IV. Clitellum thick, completely zonular, extending over 15 annuli (X b⁵ to XIII b⁴ inclusive), well defined and broader than contiguous segments. Genital orifices separated by three full annuli, the male being situated between the second and third rings of somite XII (XII b²/a²), the female at XII/XIII. On mature worms the male orifice is prominent, with rugose margins and elevated on a broad conical papilla. When the atrial chamber is everted this region appears as a slightly elliptical disk with the longer diameter transverse, with a slightly raised marginal rim, and near the center two small openings of the prostate horns. Completely quinque-annulate somites have all annuli of equal length, and not further subdivided except on much contracted specimens, which have all rings equally subdivided by transverse furrows across the middle. Anus large, with radical furrows surrounding it, situated 3 annuli in front of the anus. Posterior sucker thin, flat, its diameter about two-thirds the greatest width of the body, marked on each side by several raised radiating lines.

Color, yellowish olive or dull green, marked for the entire length with four longitudinal stripes composed of numerous small black spots with pale centers in which sensory papillæ are situated. The middle (paramedian) pair is usually the darker, and the supra-marginal duller and more diffuse, while the median light area is paler than those between the two pairs of dark stripes. Ventral surface and lateral margins plain gray or ashy and quite unpigmented. Other specimens have the dorsal pigmentation diffuse, giving an effect of dull brown or brownish black, the paramedian region being always deepest. In such specimens, the furrows are always pale, and the rings speckled with small white spots indicating the position of the sense organs.

Atrium with median chamber relatively spacious, much as in *Dina microstoma*, not deeply bilobed nor much incised by the nerve cord; prostate cornua small, curved laterally and downward to meet the vasa deferentia, which pass forward as long loops as far as ganglion XI.

Length in moderately extended resting condition 25–30 mm., maximum width at posterior end of clitellum 3 mm., greatest depth nearly 2 mm.

Egg-cases very flat, thin, yellowish, chitinous capsules, elliptical, not produced at the ends, and with slightly developed thin margins; 3–4.5 mm. long and 2–3 mm. wide. They are attached by one face to the under-side of stones, sticks, etc., and each contains several eggs or young immersed in albumen.

In the digestive tracts were found the remains of small insect larvæ, oligochaete annelids, and other leeches, including their own species.

Very abundant under rocks about the shores of Lake Amatitlan, Guatemala, associated with *Glossiphonia lineata* (Verrill) Moore. I have also received specimens from other parts of Central America, Mexico, and the mountains of southern California.

A small, slender leech, seldom exceeding 30 mm. in length, pale ashy below and of a yellowish olive or dull green color above, marked by two or four dusky longitudinal stripes, which may be diffuse and coalesced. On the head are three pairs of eyes, the first and largest on the upper lip, the other close together at the sides of the mouth. In addition to some features of the internal structure, this species is distinguished from related leeches by having all of the rings of the middle of the body of equal length and similar structure, and three complete rings intervening between the male and female external genital pores.

It abounds about the shores of Lake Amatitlan, seeking concealment by day beneath stones and similar objects in the shallow waters, and at night becoming active in the pursuit of small worms, insect larvæ, and even the smaller members of its own species, which constitute its chief food. Having no toothed jaws, it is not an habitual blood-sucker, though it doubtless, like related species, attacks abraded surfaces of higher animals when opportunity offers.

Not confined to Lake Amatitlan. It has been found through Central America, Mexico, and in the mountains of southern California, inhabiting streams as well as lakes and ponds. The eggs are deposited, several together, in a quantity of albuminous jelly, in small, very flat, elliptical, somewhat horny capsules, provided with a thin, often frilled border, and attached firmly to the under side of stones.

Type No. 2389 Collection Academy of Natural Sciences of Philadelphia.

CRUSTACEA OF LAKES AMATITLAN AND ATITLAN.

Two species of larger Crustacea occur in Lake Amatitlan, but one of these, the Freshwater Crab, occurs in both lakes. During the breeding time for these species, they form a considerable amount of the food supply taken from Lake Amatitlan.

For notes and the identification of these species I am indebted to Miss Mary J. Rathbun, of the Smithsonian Institution, Washington, D. C.

Family **Palæmonidæ**. SHRIMPS: CAMARONS.**Bithynis jamaicensis** Herbst. CAMARON.

The Camaron is a large shrimp which is quite abundant in the Pacific Coast streams of Middle America. It is now quite abundant in Lake Amatitlan, but is difficult to capture, except in April, May, and June during its breeding season. This species inhabits fresh waters from Lower California and Texas to Ecuador and Rio de Janeiro. It is also abundant in the West Indies, and wherever found it is much prized as an article of food. This large Shrimp or Camaron does not inhabit Lake Atitlan. The fact that it is abundant in the Pacific coast streams indicates that it is possibly native to Lake Amatitlan, although it is reported to have been introduced there. Lake Atitlan has no outlet, and it also has a very limited fish fauna, and so the absence of this crustacean might be expected. This Camaron is reported as abundant in the west coast rivers of Nicaragua, but is said not to occur in Lakes Managua and Nicaragua; but neither of these lakes communicates with the west coast streams. Except during the spring months, this species is said to go to deep water. At any rate they are seldom seen, or seldom captured, except during the breeding season. As an article of food, this Shrimp is very highly prized. Lake Amatitlan, abundant in breeding season.

Family **Potamonidæ**. CRABS; CANGREJOS.**Potamocarcinus guatemalensis** Rathbun. CANGREJO.

This crab is quite abundant in Lake Amatitlan, but like the Camaron is more easily captured during the breeding time, which

is in February, March, and April. The eggs of this species are laid and then attached to the legs and caudal appendages, and are thus carried until the young are of sufficient size to care for themselves. The eggs and young of the Camaron are carried in the same way. To capture these animals when thus loaded with eggs or the young means much destruction to the species. The Cangrejo is much prized for food. Individuals when taken loaded with young should at once be returned to the water. If water animals are to become abundant and useful, the wholesale destruction of the young should be avoided.

There are many species of fresh water crabs found in tropical waters, inhabiting streams, lakes, ditches and damp woods. Their food, like that of the Camaron, consists of insects and other small animals, and of water plants. Their abundance in Lake Amatitlan will depend largely upon the protection given them during the time they are taking care of their young. Lakes Amatitlan and Atitlan, common.

The smaller Crustacea were comparatively more abundant in Lake Atitlan than in Lake Amatitlan. Many hauls were made with the tow net at or near the surface at nearly all hours of the day, and never, except once, were these forms taken in any considerable quantity. On February 17th, at about 4:30 P.M., I made a surface towing in Lake Atitlan, near San Lucas, with only average results. A second short haul, made about three-quarters of an hour later resulted in securing about a pint of these small forms. This haul was made just as it began to rain. It was evident to the naked eye that the surface of the water was alive with these small crustacea. These forms were not observed to be at the surface in such numbers on several other evenings, about this same time, when examinations were made.

The collections made at both Lakes Amatitlan and Atitlan were studied by Dr. E. A. Birge, Professor of Zoölogy of the University of Wisconsin, and by his assistant, Professor C. Juday. The following account of the *Phyllopoda* was prepared by Dr. E. A. Birge.

Family **Sididae.**

Diaphanosoma brachyurum (Liéven) G. O. Sars.

A considerable number of females, not distinguishable from the North American representatives of this species, as found

in the collections from Lakes Atitlan and Amatitlan. Length 1.0 mm.; height to 0.45 mm.

Family **Daphnidae.**

Daphnia pulex De Geer.

By far the most abundant member of the *Cladocera* in the collection is a stout, semi-transparent representative of this species. The antennæ are not very strong, and only slightly ciliated. The first and second abdominal processes are united at the base. There are 17-18 abdominal teeth. The distal pecten bears 6-8 teeth, of which the proximal is smaller than the others. The proximal pecten has about 10 small teeth. Length to 2.5 mm.; height to 1.6 mm. Lakes Atitlan and Amatitlan.

Daphnia longispina O. F. Muller.

A single specimen of this species was found in the collections from Lake Amatitlan. It is of the variety *galeata* Sars, and is not far from the form figured in Lilljeborg's *Cladocera Sueciæ*, Pl. XVII, fig. 9. Length 1.56 mm., including spine 0.4 mm. long; height 0.53 mm.

Ceriodaphnia rigaudi Richard.

Four immature specimens of this species were found in the collection from Lake Amatitlan. They included both varieties, three having one horn, and one specimen having two horns on the head. Length 0.4 mm.

Family **Bosminidae.**

Bosmina obtusirostris G. O. Sars.

A few specimens indistinguishable from this species were found in both lakes. Length 0.42 mm.

Family **Lynceidae.**

Alona, sp.

Two immature specimens of a species of this genus were found in the collection from Lake Atitlan. Length 0.3 mm.

The following account of the *Copepoda* was prepared by Professor Chauncy Juday, of the University of Wisconsin.

In the Plankton collection, from Lakes Atitlan and Amatitlan, the *Copepoda* are represented by only two forms.

Family **Centropagidæ.**

Diaptomus albuquerquensis Herrick.

Four specimens of this species were found in the material from Lake Atitlan, and four in that from Lake Amatitlan. Length 1.4 to 1.7 mm. This form has been reported from Colorado, New Mexico, and the City of Mexico.

Family **Cyclopidae.**

Cyclops oithnoides Sars.

A few adults were found in the collection from Lake Atitlan. Length 0.5 mm. A considerable number of immature specimens, which probably belong to this species, was found in the collections from both lakes.

SHELLS OF LAKE AMATITLAN.

With the exception of one species, *Sphæromelania largillierti*, shells are not abundant about the shores of the lake. No bivalves were taken, and probably none exists there. My stay at Lake Atitlan was short, and no shells were collected there. The few unsuccessful searches made for these indicate that shells are not abundant on the shores of this lake.

For the identification of these shells I am indebted to Dr. Dall and to Dr. Bartsch, of the Smithsonian Institution.

Family **Melanidæ.**

Sphæromelania largillierti Phil.

This is the largest and by far the most abundant species of shell found in the lake. It is found everywhere along the shore

on plants and rocks. This species deposits its eggs in January and February. The eggs are very large and are usually attached to the under side of rocks. This species is so abundant that its large gelatin-like eggs would furnish a considerable amount of food for small fishes. It is a very abundant species in Guatemala and San Salvador to Central Nicaragua.

Family **Amnicolidæ.**

Amnicola guatemalensis Fisch & Crosse.

A very small species and very scarce. Of no economic importance.

Amnicola petensis Morelet.

Very small and very scarce. Of no value.

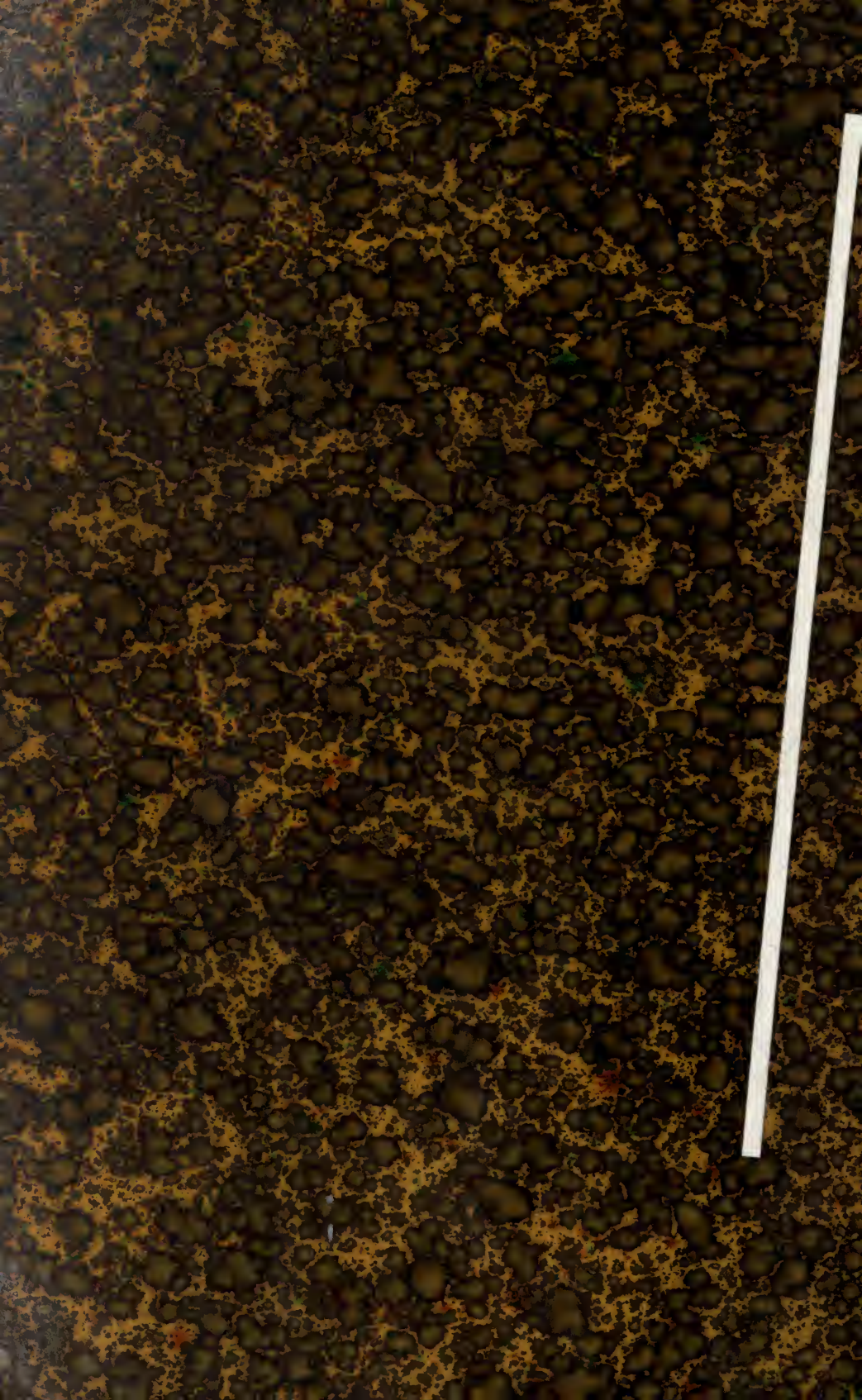
Family **Limnæidæ.**

Ancylus excentricus Morelet.

Very small and very scarce. It is found attached to rocks.

Planorbis subpronus Von Martens.

Very small, rather common. Of no economic importance.



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